

# DOES THE REGIONAL MYTH STILL HOLD?

## —AN INTERIM REPORT

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### Executive Summary

This paper introduces our ongoing analysis of auto component development data obtained from Nishiguchi's research sponsored by MIT's International Motor Vehicle Program (IMVP)<sup>2</sup>.

The main results of this paper can be found in the section of Research Results where a regression analysis of auto component development productivity is conducted. There are three major findings:

1. Contrary to the general perception, neither component type nor generally accepted project characteristic governs variations of productivity among auto component projects in our study.
2. Even after correcting for component type and differences in project characteristics, there still remains a strong regional gap in productivity between Japanese and Western samples (North America and Europe).
3. Among Japanese suppliers, a counterintuitive relationship between person hours and unique parts ratio was revealed: There is a tendency that person hours decreases as unique parts ratio increases. This relationship should not occur without continuous accumulation of knowledge on the auto components. Nor is it explained solely by a cross-functional feature of organizations.

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<sup>2</sup>The IMVP's support over the last four years, as well as its sponsors' cooperation, is gratefully acknowledged. Although far more limited in scope and depth, a preliminary study was also conducted by the first author with the support of INSEAD and its Euro-Asia Centre between 1990 and early 1991. (Mark Fruin participated in that preliminary stage.) For earlier versions of this paper, Michael Cusumano and Takahiro Fujimoto provided invaluable suggestions from which we are grateful.

# Normalizing Auto Components

Compared with automobile projects, representativeness can be more of a problem for auto components. This is because of the fact that the number of components can range from several to thirty thousand in an automobile depending on the measurements employed—and compounded with the component’s variety from transmissions to body panels to seats to wire harnesses to radios to wind shields to tires to paint to fasteners. A set of concepts was developed to normalize this problem.

Two concepts, external (or interfunctional) complexity and internal (or intrafunctional) complexity<sup>3</sup>, were developed to help normalize differences in configuration, material, function, and importance of various components with specific reference to (1) a given component’s interfunctional dependence in design specifications on other areas of components, and (2) its self-contained technological complexity independent of other areas. First, external (or interfunctional) complexity is defined as the degree to which the design features of a given component are interdependent on those of other components and/or functional areas within a motor vehicle. The more interdependent a given component is, the more coordination among various functions and organizations is necessary for successful design performance. Conversely, if a component is closer to the stand-alone spectrum, less organizational coordination is prescribed.

Second, internal (or intrafunctional) complexity refers to the degree of complexity to specify a component’s design details within itself.

In this study, it is assumed that choosing several types of components with different locations on a “spectrum” of external and internal complexity provides a proxy for reasonable representativeness without invoking prohibitive operational problems. Subsequently, four auto components were selected: the engine control system, the air conditioning unit, the brake system, and the sound system. It was estimated that the external and internal complexity of these four components would gradually decline on the spectrum from the engine control system to the sound system in that order. If this gradation would be ob-

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<sup>3</sup>These concepts differ from and are deliberately simpler than “internal and external integrity” as “organizational mechanisms” (Fujimoto, 1989:31, 33; Clark and Fujimoto, 1991:24-25, 30-31; Fujimoto, Iansiti, and Clark: 1992:26, 28-41), or “cross-functional interdependency” and “inter-project interdependency” (Nobeoka and Cusumano, 1992:30), which are also organizationally embedded. It should further be emphasized that the concepts developed here do not portend a comprehensive model to categorize all auto components under a simplistic scheme, which some have attempted unsuccessfully. Rather, as will be discussed, the primary objective of external and internal complexity is, simply, to identify and measure the spectrum of representative auto components for this study.

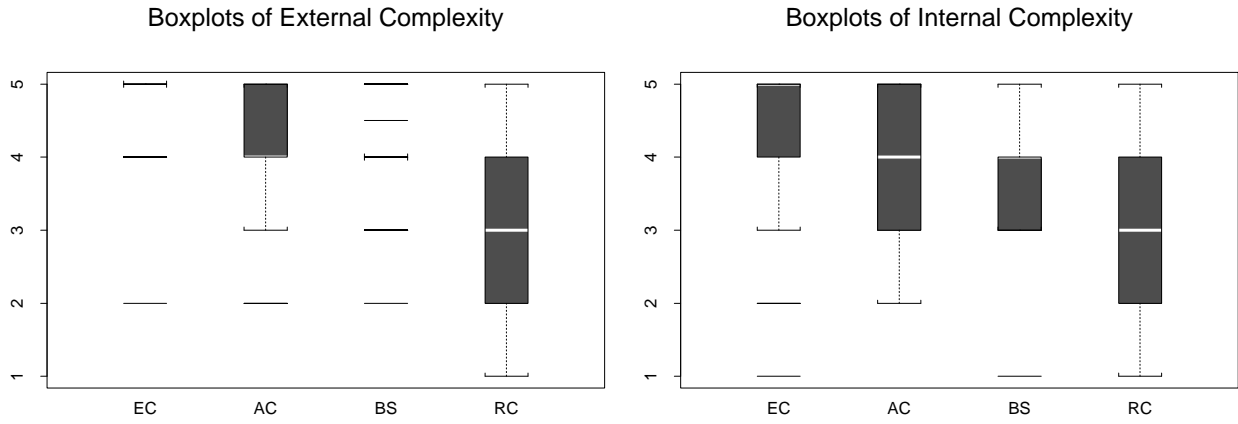


Figure 1. External Complexity and Internal Complexity <sup>4</sup>

tained, it would be expected that the four components represent different modal types to study and that biases by selecting particular components offset one another.

By and large, the assumptions made were supported by the assessments of auto project development engineers from a number of automakers in North America, Europe, and Japan (Figure 1). For each of the four components, the respondents estimated, on a 1-5 scale, the external complexity and internal complexity involved in designing and developing a typical component product as part of a new auto development project. Among the four components, the engine control (EC) unit is considered to be most externally and internally complex, followed by the air conditioning (AC) unit and the brake system (BS), and then by the radio/cassette (RC) combination unit.

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<sup>4</sup>Boxplots allow simple comparison of several batches of data. The median of the data is marked with a white stripe in each “box”. The lower side of the “box” is the first quartile and the upper side is the third quartile. Thus the “box” represents the middle half of the data. Dashed “whiskers” run from the quartiles to the nearest values not beyond the standard range which is defined as  $1.5 \times (3\text{rd quartile} - 1\text{st quartile})$ . Values beyond the standard range are plotted individually with a line. Several “boxes” and “whiskers” in Figure 1 degenerate to “H” shape, since the first quartile and the third quartile of the corresponding batches are equal. Similarly, a one-sided “box” occurs when the median and the first (or third) quartile coincide.

# Key Characteristics of the Project Studied

This section summarizes some of the key characteristics of the auto component projects studied in four aspects: design derivation (design newness), design scope (supplier design ratio), unique parts ratio, and variants.

A design of an auto component is defined as a new design if it entails more than seventy percent of the comprised part numbers being designed out of scratch (measured by fraction of part numbers). Supplier design ratio is the proportion of design characteristics detailed by the supplier measured by fraction of part numbers, while unique parts ratio is the proportion of parts specific to a given project (as opposed to parts common to other projects) also measured by fraction of part numbers. Finally, variants counts aggregate number of final component variants derived from an auto component project.

These four variables differ from one project to another and affect each project's productivity. Thus, it is prerequisite to correct for these differences in a given project in order to compare on the same technical plane.

## Research Results

This section presents the regression analysis of productivity for the auto component development projects covered in this research. The data consist of 78 sample projects in which 19 North American, 40 Japanese, and 19 European projects are included. As for component type, 19 projects are EC, 22 projects are AC, 22 projects are BS, and 15 projects are RC.

The total number of person hours spent on each project is used to measure development productivity. Since the distribution of person hours is heavily skewed to the left, the log-transformed person hours is employed as the dependent variable.

There are four groups of explanatory variables considered in our analysis:

**Group 1** Dummy variables for AC, BS, and RC components. Thus, variation explained by EC is included in the intercept.

**Group 2** A dummy variable for new design (ND); supplier's design ratio (SDR); unique parts ratio (UPR); number of component variants(CV).

**Group 3** Dummy variables for Japanese suppliers and for European suppliers.

**Group 4** Proportion of cross-functional personnel involved (CFR).

All the regression models in this paper include Group 1 and Group 2 in order to correct for differences in component types and in project characteristics.

First regression model (LPH1) includes only Group 1 and Group 2 (Table 1 in the Appendix). The F-test rejects the hypothesis that any one of regression coefficient is nonzero at 5% significance level. Contrary to the industry-wide assumption, variations of person hours due to component types and generally accepted “key” project characteristics turn out to be negligible.

Second regression model (LPH2) shows cross-regional differences in log person hours corrected for component types and project characteristics (Table 2 in the Appendix). In addition to Group 1 and Group 2, Group 3 is included in the model. The significance of the regression model results in a large value of F-statistic whose p-value is 0.0045. As for regional gaps, only the indicator for Japanese group shows significant negative difference from average log person hours in North America at level 5%. Thus, on average, Japanese suppliers stand out in productivity compared to those in two other regions even with adjustments for component types and project characteristics.

It is worth emphasizing that unique parts ratio turns significant at level 5% with the existence of regional group variables. Regional breakdowns of scatter-plot which depicts log person hours versus unique parts ratio visualize the hidden structure suggested by the regression result (Figure 2). Unlike the other two, the scatter-plot for Japanese suppliers shows explicit decreasing trend of person hours as unique parts ratio increases. This rather counterintuitive relationship between person hours and unique parts ratio brings out the negative coefficient for UPR in Model LPH2.

What makes it possible to improve productivity while spending more design and engineering efforts to incorporate more unique parts? It seems prerequisite to accumulate understanding of both interfunctional and intrafunctional aspects of a component in order to accomplish this rather contradictory result.

Third regression model (LPH3) replaces Group 3 by Group 4. It is well documented that multiproject and/or cross-functional organization can maximize the use of existing manpower by deliberately creating interunit permeability. Cross-fertilization across units and functions facilitates the fusion of new ideas expressed by those involved in other projects and functions. Multiproject involvement particularly helps concurrent transfer of knowledge and information acquired in one project to another.

The result is summarized in Table 3 in the Appendix. It follows from the F-test that the explanatory variables as a whole have significant contributions to variations of log person hours at level 5%. As for individual explanatory variables, CFR appears

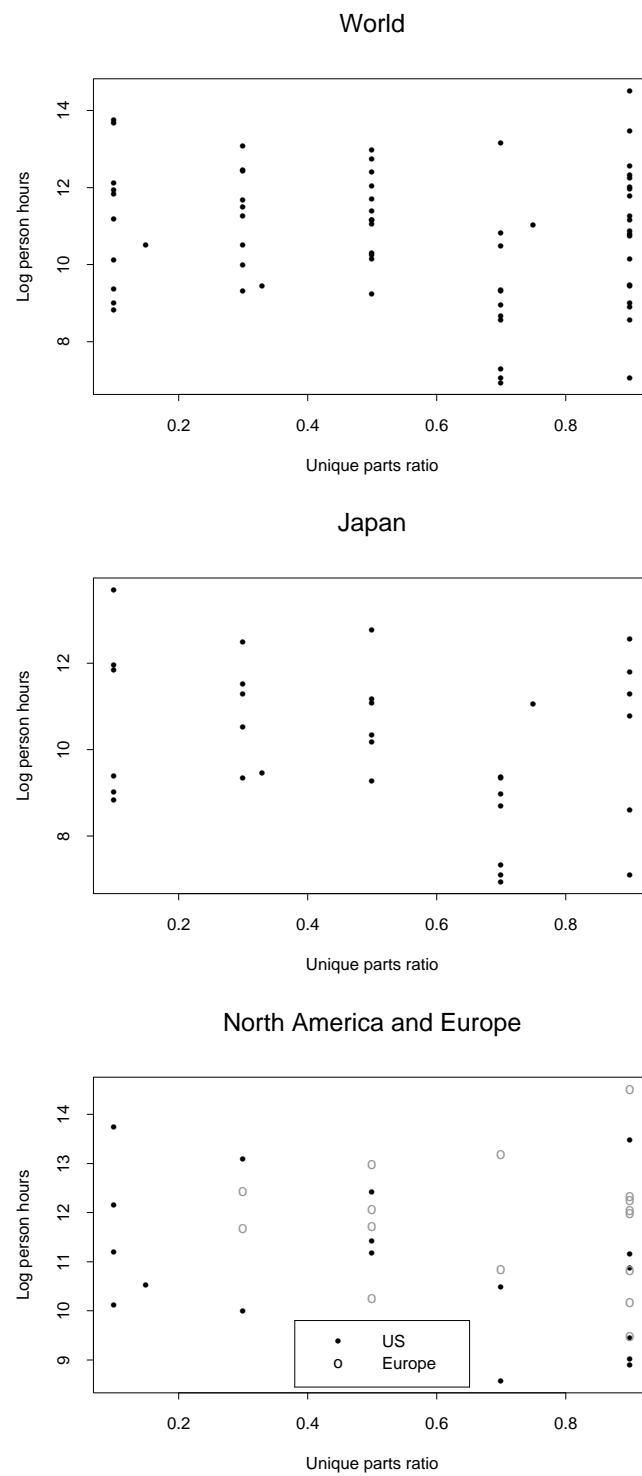


Figure 2. Breakdowns of Log Person Hours vs. Unique Parts ratio by Region

significant at level 5%, though the significance of UPR is not so strong as in Model LPH2.

## Implications and Future Research

Our results do not deny the importance of strategic control on design variation, design scope, unique parts ratio, and variants. Rather, it implies the existence of other factors well controlled in a region and not in others. We consider that those factors are intraorganizational or interorganizational between assemblers and suppliers, and deeply relate to the accumulation of shared knowledge. Identification of those factors will be the next stage of our analysis.

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# Appendix

Residual Standard Error = 1.648

Multiple R-Square = 0.1087

F-statistic = 1.2191 on 7 and 70 df, p-value = 0.304

	coef	std.err	t-stat	p-value
Intercept	10.9971	1.0200	10.7818	0.0000
AC	0.0411	0.5777	0.0712	0.9435
BS	-0.7746	0.5477	-1.4143	0.1617
RC	-0.9369	0.6817	-1.3744	0.1737
ND	0.3512	0.4656	0.7543	0.4532
SDR	0.2274	0.9955	0.2284	0.8200
UPR	-0.7910	0.7354	-1.0756	0.2858
CV	0.0131	0.0112	1.1694	0.2462

Table 1. Regression results for Model LPH1



Residual Standard Error = 1.4983

Multiple R-Square = 0.2843

F-statistic = 3.001 on 9 and 68 df, p-value = 0.0045

	coef	std.err	t-stat	p-value
Intercept	12.1567	1.0351	11.7440	0.0000
AC	-0.2696	0.5443	-0.4953	0.6220
BS	-0.4657	0.5037	-0.9245	0.3585
RC	-0.8804	0.6215	-1.4164	0.1612
ND	0.5517	0.4296	1.2842	0.2034
SDR	0.1341	0.9054	0.1481	0.8827
UPR	-1.7452	0.7103	-2.4572	0.0166
CV	0.0009	0.0108	0.0882	0.9300
Japan	-1.1828	0.4956	-2.3863	0.0198
Europe	0.6701	0.5284	1.2681	0.2091

Table 2. Regression results for Model LPH2

Residual Standard Error = 1.5684

Multiple R-Square = 0.2042

F-statistic = 2.213 on 8 and 69 df, p-value = 0.0367

	coef	std.err	t-stat	p-value
Intercept	12.4035	1.0868	11.4129	0.0000
AC	0.0439	0.5498	0.0799	0.9366
BS	-0.0909	0.5728	-0.1587	0.8744
RC	-0.6513	0.6563	-0.9924	0.3245
ND	0.3872	0.4433	0.8734	0.3855
SDR	-0.5260	0.9829	-0.5351	0.5943
UPR	-1.4331	0.7346	-1.9508	0.0551
CV	0.0161	0.0107	1.5096	0.1357
CFR	-1.7208	0.5979	-2.8779	0.0053

Table 3. Regression results for Model LPH3